ANALYSES

OF THE

WATERS IN THE VICINITY OF CINCINNATI;

REPORTED TO THE

TRUSTEES

OF

THE CITY WATER WORKS,

BY

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REPORT

OF

PROF. LOCKE & SON,

ON THE

ANALYSES OF THE WESTERN WATERS.

Laboratory of the Medical College of Ohio,
June 14th, 1853.

To the Trustees of the Cincinnati Water Works:

Gentlemen—Lewis Warden, Esq., Superintendent of the City Water Works, having, at your order, put into our hands, on October 9th, 1852, several specimens of water from the Ohio River and other places, with the request that we analyze the same and communicate the result to yourselves, permit us to present the following as our

REPORT:

In undertaking the analyses of the various available waters by which our city can be supplied, we are impressed with a view of the subject which does not at once strike every one on the suggestion of such a work; although undoubtedly it has presented itself to the Trustees of the Water Works, who have directed its execution. The analysis of the waters of rivers and fountains is a part of the science of the world, and is important as having a considerable weight with regard to the health and diseases of those who use it; it is thus one of the conditions of human happiness. The analyses, besides their general scientific results, will settle questions of pecuniary importance likely to be agitated directly by our city authorities. It is evident that our city might be supplied copiously with water from either of the Miamis, by natural hydraulic descent, without the expense of steam power, and if the waters were sufficiently pure the question might be agitated; but by the analyses the water of either of the Miamis is shown to be too highly charged with mineral matter to answer well for domestic use. Thus is an important question put at rest at once.

Scientifically, the analyses are important in showing the relation between the waters of rivers and the geological strata through which they run. It is evident that the composition of the water will vary with the stage of the river as being high or low. But as sometimes happens one tributary, as the Allegheny, the Monongahela, the Kanawha, the Big Sandy, the Scioto, the Miami, or the Licking will be locally in flood, while the other streams are low, when it is evident that the composition of the water in the channel of the Ohio will approach that of the river or tributary whence it comes. But at the lowest stage of summer drought it may be

assumed that the conditions are nearly uniform and constant, and that the results in different years will be nearly identical. Hence, when the work of analysis has been once performed under these conditions it can forever after be refered to as a standard of comparison.

From these and other considerations we were led to attach more importance to the task than popularly would be seen cause for, and to devote so much time as would enable us to do the subject justice.

There are still several desiderata in reference to the qualities of our waters. It would be desirable that we have the composition of the water at full flood, at half flood, as well as at extreme ebb, and that we have an analysis of the Ohio water above the point where it begins to receive waters from the limestone region as above the Scioto River. Indeed we have in part supplied this deficiency by taking some water from the Ohio at a point about twelve miles below Big Sandy River, early in May of this year, and examining the quantity of lime which it contains. This analysis may be taken as a sample of the waters of the sand stone or coal region of the upper Ohio.

The following general classification has for its foundation the degree to which the several waters are impregnated with foreign materials, beginning with those containing the least.

CLASSIFICATION OF NATURAL WATERS.

FIRST.—*Aqua Atmospherica*, or atmospheric water, including rain, hail, snow, dew and frost. These are the most pure forms in which natural waters can be obtained, still they often contain foreign matter derived from the atmosphere and whatever may be floating in it.

SECOND.—*Aqua Fluviatalis*, river water. The impurities of this vary much according to circumstances, especially by the nature of the soil and rocks whence it is derived.

THIRD.—*Aqua Fontana*, spring and well waters. These are the chief source of streamlets and rivers, but as the waters are supplied to them immediately from the rocks, the clays, the sands, and the soils where they are located, they are less pure than river waters; for in their course the water of rivers deposite much of the foreign matter which they receive at their fountains.

FOURTH.—*Aquæ Medicinales*, medicinal or mineral waters. This name is given to such waters as are charged with such ingredients, and to such an extent as to produce peculiar effects on the human system. Sometimes they have a temperature unusually elevated, when they are called thermal waters. Mineral springs have ever attracted great popular attention, and their analyses have been studiously preserved, while authors are faulty in not recording more of the analyses of river waters in common domestic use.

FIFTH.—*Aqua Oceanica*, sea water. As all saline matter entering springs and rivers is carried more or less to the ocean, whence the water is evaporated or distilled into the atmosphere to be precipitated at the

heads of rivers in a pure state, leaving, always, the saline matter behind; the ocean may be supposed to be continually becoming more and more saline and concentrated. In some small seas or lakes, having no outlet, and around which the earth is charged with saline matter, the water becomes highly impregnated even to saturation: as in the case of some lakes in Persia, the Dead Sea, and in the great Salt Lake of America.

From this view it appears that the dry land of the earth is undergoing a perpetual washing and freshening by atmospheric waters, and the materials carried into the ocean, mechanically and chemically, are, according to the doctrines of geology, settled and crystalized into strata, ultimately to be raised up by some force of nature unknown to us, and to form, in their turn, dry and habitable land.

This land would of course emerge saturated with all of the oceanic salts, which must be dissolved slowly away by the streams and rivers which must necessarily be formed.

The sources of the Ohio are from a region not yet quite washed of its original oceanic solution; for the salt-borer still finds between the ledges of sand stone, at depths not very considerable, veins of the original brine having all of the elements of the present sea water. Even certain springs called licks are still supplying salt water to the river, and hence muriate of soda, or common salt, is detected in its waters.

By this upheaval of strata from the depths of the ocean it is that the continued contribution of the land to the sea is restored, and that action which seemed to tend constantly to an ultimate extreme, becomes a revolution returning into itself and preserving an equilibrium which would otherwise unballance the present condition of things. We have not yet discovered the laws of this revolution as we have astronomical periods, but no doubt those laws exist.

SOME SPECIAL CIRCUMSTANCES WHICH MODIFY WATERS.

Well and spring waters from large cities generally contain nitrates, which arise from the rapid oxidation of nitrogenized organic matter. These nitrates in the water prevent the formation of any vegetable matter, which cannot be detected by the microscope even after it has been long kept.

According to Heinrich Rose, of Berlin, "the silicic acid (flint) which exists in water, is probably in most cases one of the constituents of the organic substances, and that it is partially owing to animalculæ with silicious (flinty) coats, (Bacillariæ and Naviculæ.") But some of the silica (flint) is most undoubtedly derived from the burning of vegetable matter on farms; the potassa and the silica of the ash fusing together in combustion become soluble and are carried by rain water percolating the soil into the springs, and thence into the rivers.

WATER AS A SOLVENT.

We scarcely think of water as an active chemical agent, while the fact is its powers as a solvent are very extensive over solid, liquid and gaseous forms of matter.

In some cases pure water dissolves a substance directly, as in the case of gypsum, while in other cases water in order to become a solvent must first combine with some other substance as in the solution of limestone by first combining with carbonic acid. Pure water scarcely acts upon limestone, but that which has first absorbed fixed air, will then dissolve a hundredth portion of limestone, and becomes what is called "limestone water." As heat will expel this extraneous or absorbed carbonic acid, the limestone water when boiled loses one portion of its acid, and with it the power of holding the lime any longer in solution; it thus becomes milky and the lime is deposited as a crust upon the inside of the boiler, as the tea kettle or the steam boiler. As lime is a common ingredient in waters of limestone countries, it becomes an enquiry, how does the water acquire the carbonic acid, by virtue of which it dissolves the lime of limestone. It derives it in part from the atmosphere, but mostly from the soil, especially from the black mould formed by the rotting of leaves, wood, &c. Water passing through the decaying substance in the soil acquires carbonic acid and then dissolves the first lime it meets with, holding it in solution as bicarbonate of lime, or lime with a *double* dose of carbonic acid. Cold springs, in this part of Ohio, are often abundant in this dissolved limestone, but as soon as the water is discharged to the open air and becomes warm, as in the sun, bubbles of gas escape and the water becomes milky by deposited lime. The streams in which this action goes on deposit a crust on the pebbles over which they run, and sometimes cement those pebbles together. In this manner the waters of the Little Miami, for example, might deposit much of their lime by running in a shallow stream over pebbles heated by the sun.

From the above it will be perceived that when the property called hardness of water is owing to the presence of bicarbonate of lime, it can be remedied by boiling the water, which dispels one half, or one dose, of the carbonic acid, and the lime will then settle as a proto carbonate of lime. When this hardness is owing to the presence of sulphate of lime (gypsum), an addition of carbonate of soda will precipitate the lime as a proto carbonate; the sulphuric acid which was united with the lime combines with the soda, whose carbonic acid has united with the lime.

It may not be inappropriate to make some remarks on the details of the present work.

The waters and their histories were furnished us by Lewis Warden, Esq., Superintendent of the City Water Works.

After having filtered the mechanically suspended matter from these, we took five portions of each to experiment upon; those little imperfections which we discovered during these experiments are noted under the head of "History and Remarks." The sulphuric acid was obtained from one lot of water, the chlorine from another, a third was used to obtain the solid matter—from this residuum or solid matter the lime, etc.,

was determined. A fourth lot of water was taken from which to procure the potassa; a fifth was used as a check upon the results obtained from the above.

The object in using so many portions of water was to avoid the accumulation of impurities from tests, although the tests were tested themselves. The filters used for filtering the acid solutions were mostly washed with hydro-chloric acid previous to experimenting with them, except those for collecting the precipitate of chlorine, in which case nitric was substituted. These rules were adhered to in all cases but one, which is doubtful. (See spring water, page 3.)

As most substances combine in known proportions only, it becomes unnecessary to separate them in analysis in order to know the quantity of each of the constituents, these last being ascertained by calculation. Thus when we obtain a given weight of proto carbonate of lime we know that the carbonic acid and the lime exist in it in the proportion of 22 of the former to 28 of the latter, and whatever may be the weight obtained we separate it into two quantities by calculation, which shall have the above proportion, calling one carbonic acid and the other lime.

In the determination of potassa, we have it in the form of potassa chloride of platinum, in which the potassa bears the proportion of a little less than one-fifth of the whole, and as we weigh the precipitate within less than a thousandth of a grain,* we weigh the potassa within less than two-tenths of a thousandth of a grain. With regard to lime, it is a little more than half of the compound from which we estimate it, or in the ratio of 0,562 to 1. Silica (flint) we procure in its pure state, but magnesia in a combination of which it is somewhat more than a third, or as 0,367 to 1. Alumina (clay), like silica, is procured in an uncombined state. Magnesia in this case was determined in a compound of which it formed less than two-thirds. Iron is generally procured as a per oxide. The sulphuric acid was estimated from a precipitate of sulphate baryta, which is slightly more than one-third sulphuric acid; and the chlorine from a compound of silver, of which it forms less than one-fourth, &c. From this view of the subject it is evident that the results can be attained to a degree of minuteness unperceivable by the balance: as in the case of potassa mentioned above, if the precipitate be one-thousandth of a grain, which is weighable, then the potassa will be two ten-thousandths of a grain, which is calculated though not weighable. The balance used was made by Robinson, of London, and so nicely suspended on jewels as to turn decidedly with the one-thousandth part of a grain.

After having procured the amount of acids and their bases, the analyst has then followed nature as far into her mysteries as he can with perfect assurance of his being correct. When he combines these acids and bases, he does so on hypothesis, although he is most likely correct, as he has

* If you take a fine human hair and cut off a piece a little less than three-tenths of an inch in length you will have about a thousandth of a grain.

circumstantial evidence for what he does, yet he lacks that direct and decided proof which has guided him in all his former steps.

As the use of lead for pipes, cisterns, &c., in connection with the Ohio water, is a subject of general interest, we made some slight experiments with regard to this point. We therefore beg leave to introduce some general remarks and practical suggestions upon the use of that metal.

We find the use of lead for conducting water, condemned by the Roman architect Vitruvius, who it is supposed flourished in the age of Cæsar and Augustus. He says "cerusse is formed which is hurtful to the human body." Gallen also censures the use of lead pipes. There is but little more than repetition of the above statements till the close of the last and the commencement of the present century, since which time science has unraveled the laws that regulate the actions of lead and water.

Spring and river waters which contain minute portions of neutral salts, form insoluble compounds with the lead which would coat a cistern; pure water dissolves the oxide of the metal which remains in solution until it is precipitated, by the carbonic acid of the air as a carbonate of lead; but lead is not dissolved by pure water when the atmosphere is excluded as it furnishes the oxygen to form the lead into an oxide previous to its solution.

The acetate of soda but imperfectly prevents the formation of the solution of the oxide of lead; when a hundredth part of the acetate of soda is dissolved in water lead placed therein loses about one-fourth of what it would in distilled water in the same length of time. On the contrary, arsenite of soda is a complete preservative when dissolved in the proportion of a twelve-thousandth part. Phosphate of soda and hydriodate of potassa are almost as effectual preservatives in the proportion of a thirty-thousandth part only of the water. It requires a two-thousandth of chloride of sodium (common salt) and a four-thousandth of sulphate of lime. Nitrate of potassa (nitre) is but little superior to the acetate of soda; when water contains a hundredth part of this nitrate it almost entirely prevents any action; but if the quantity be reduced to a hundred-and-sixtieth the loss sustained by the lead is fully a third of that dissolved in distilled water.

Chirstison makes the statement that water which contains a ten-thousandth or a twelve-thousandth of salts may be safely conveyed in lead pipes, if the salts in the water be chiefly carbonates and sulphates: that lead pipes cannot be safely used when it contains a four-thousandth of saline matter, if this consists chiefly of muriates (chlorides).

By the above rule we are within the bounds of safety in conveying the Ohio water in lead pipes even when we leave off the salts of soda. (See remarks and experiments on the water of the Ohio.)

Water in leaden vessels is sometimes contaminated by the effects of the galvanic current which generally requires the presence of two metals, viz: lead and the solder, which is used to unite it; this is probably a source of galvanic action in cisterns, also, the iron, copper and brass rods and wires

which are used therein. This electrical action may take place even without the presence of another metal, by parts of the same piece of lead, for example, being of a different quality caused by more or less impurities, and thus acting as different metals; this will explain why sheet lead corrodes sometimes in spots when exposed to the air or water.

Lead-lined cisterns, to contain water for culinary purposes, should always be filled nearly to the top, and should not have lead covers, for the water is slowly evaporated and then condensed on the metal, thus covering it with distilled water which dissolves the oxide and accumulating drops into the cistern, carrying the dissolved lead with it. The equilibrium of the water can be easily maintained where the cistern is supplied by a pipe by using the common automatic ball and stop-cock.

A remarkable instance of the above mode of poisoning is mentioned by the Compte de Milly, in a paper read by him before the Academy of Sciences, at Paris. About a year after having two leaden cisterns placed in his house, to hold the water of the Seine for domestic purposes, he was attacked with severe and obstinate colic. This led him to examine his cisterns; he found that the sides where they were occasionally left exposed by the subsidence of the water, and more especially the tops were covered with a white liquid which was constantly dropping into the water of the cisterns which gave decided evidences of lead. But the Seine contains such an amount of salts that it will not dissolve lead placed within it.

Rain and snow waters should never be retained in leaden cisterns, as such waters are of sufficient purity to dissolve the coating; nor should water collected from buildings covered with lead be used for general domestic purposes. This was forcibly illustrated at Amsterdam, at the time such roofs were substituted for tiled ones in that city. The lead colic became general and committed great ravages. This was undoubtedly caused by the water which was collected from the roofs for culinary purposes; the same is mentioned as having occurred at Harlem.

HISTORY OF THE SPECIMENS ANALYZED, WITH REMARKS.

[In the arrangement of the tables the waters analyzed by ourselves are placed in the order of their purity, the purest being in column A &c.]

OHIO RIVER WATER, TWELVE MILES BELOW BIG SANDY RIVER.

Column A. in the Tables.

The object in taking the water of this part of the Ohio was to procure the analysis of its waters before their entrance into the limestone region. The specimen was collected May 7th, 1853, in the middle of the river, five feet below the surface, the river being in a "medium stage." It is the purest water that we find in this collection of "western waters," and contains less solid matter than is found in the Schuylkill river; it also possesses the strange characteristic of being an alkaline water.

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WATER FROM THE OHIO RIVER AT CINCINNATI.

Column B. in the Tables.

The Ohio River water was taken from a hydrant on Third or Symmes street, on the 23d day of October, 1852, the river being like the others low and quite clear. This as its position indicates is the second in purity, not containing more than one-half the foreign matter found in the best of the remaining specimens, and when compared with the analysis of Croton River, (No. 2, Table II,) by Prof. Silliman, jr., we are astonished at the close resemblance. The solid matter from a gallon of Ohio water exceeding that of the Croton by only 0,076, *seventy-six-thousandth of a grain;* but it contains fifty per cent. more than the Schuylkill. We find the same constituents in the Ohio and Croton rivers, with the exception that in the Ohio we have potassa, which is not reported as having existence in the Croton water,—whilst the last mentioned contains phosphate of alumina, which is not found in the Ohio, at least, in the specimen which we examined.

EXAMINATION OF THE WATER OF THE OHIO WHICH HAD BEEN RETAINED IN LEAD CISTERNS.

We took some water of the Ohio from a leaden cistern (Analysis No. 15) which had been used for several years, and the water taken from it had remained there for two months. On evaporating we found no lead, but 3,672 grains of solid matter to a gallon of the liquid. We then took 25 grains of the sediment from the same cistern, in which there was 0,294 grains of lead, or 1,176 per cent. It is evident from the preceeding that the salts in the water prevented the solution of the oxide of lead, and at the same time purified instead of contaminating the water; this last is clearly shown, as regards other materials, by the small quantity of solid matter per gallon, which is less than that found in the water of the Schuylkill river.

Water was taken from another cistern, which was comparitively new, in which the water examined had remained about six weeks. It was found to contain the slightest imponderable trace of lead. This was probably owing to the acid compound used when the joints were soldered. In both of these specimens of water there was a slight opalesence supposed to be caused by lead. When lead was not found in one of them we were at considerable of a nonplus, but contrary to expectations the opalesence proved to have its origin from the presence of tin derived from the solder. It was in the proportion of a nine-hundred-and-fifty-thousandth part of the water. Too much reliance must not be placed upon the results of these few experiments, for many circumstances beyond our knowledge may have modified the results, such as the presence of foreign materials in the cistern,—nor are we aware of the "stage of the river" at the time these cisterns were filled.

The field is a wide and fertile one, much of interest and importance is connected with it. It seems from our experiments that there is, in

leaden cisterns holding the Ohio water, sediment which contains lead, and as this sediment may be agitated and present itself in the water, there might be danger in using it. When a pipe descends from a cistern and the water is drawn from the lower end of it, sediment might accumulate during the night and be drawn at the first opening in the morning. As there are several ways in which it is possible to receive the lead poison from lead-lined cisterns, the use of the water which they contain should be avoided if possible. Prof. Mussey informs us that he has seen symptoms of lead poison in Cincinnati and has detected the metal in our hydrant water, when retained in a cistern, and, also, when conducted through long leaden pipes. But such cases are not common.

LITTLE MIAMI RIVER WATER.

Column C. in the Tables.

The water of the Little Miami River was procured from the centre of the stream, and in a fair current, on the 27th day of September, 1852. The specimen was in a stone jug, tightly corked and sealed; it is next to the Ohio water in purity, differing from it widely by having over a hundred per cent. more solid mater, and a large quantity of potassa and phosphates, in the last named varying from all the others. So large was this yield of phosphates that it led me to make another analysis for them in particular. This large quantity of phosphates in the water may very naturally account for the great fertility of the bottom lands of that stream, which are subject to inundation.

WHITE WATER RIVER.—(SECOND SPECIMEN.)

Column D. in the Tables.

This specimen was brought to the Laboratory in a glass demijohn, tightly sealed. After having made the examination of the first specimen (column I.) it was thought advisable to analyze a second, on account of accidental impurities which the first contained.

This analysis should not be taken strictly in comparison with the others as the water was collected at a different stage, and at a different season of the year.

WATER FROM THE GREAT MIAMI BELOW THE JUNCTION WITH MAD RIVER.

Column E. in the Tables.

This water was taken in a brisk current on the 29th day of September, 1852.

It was placed in two porter bottles. When it was poured out there was a slight smell of hydrosulphuric acid, which was undoubtedly owing to the decomposition of organic matter left from the porter or ale which the bottles had contained; indeed, this is somewhat confirmed by the fact that, when pouring out the water, there escaped from the bottle a membranous substance, which, upon examination, proved to be non-vital vegetable matter. I do not think it has materially effected the result of the analysis.

GREAT MIAMI ABOVE MAD RIVER JUNCTION.

Column F. in the Tables.

This, like the preceeding, was taken from the stream in a brisk current, on the 29th of September, 1852.

There is nothing striking in this water, except its hardness.

The chemist, Brand, in speaking of the Thames river, which supplies the greater part of the city of London with water, says: "The saline contents of a gallon of Thames water do not exceed 24 grains, which in its purest state fall short of 16 grains, and this is chiefly carbonate of lime, with chloride of sodium (common salt) and chloride of magnesium." It will be seen that there is a resemblance in this Thames water to the waters of the Miamis, which might be expected, as they all have their source in rocks of a similar kind.

MAD RIVER WATER.

Column G. in the Tables.

This water was taken from the stream, in a brisk current, on the 29th day of September, 1852. It is the most thoroughly impregnated with foreign substances of any of the river waters we have analyzed or seen reported.

The Miami rivers have their sources in the cliff limestone region, where the rocks abound more or less with magnesian limestone, and hence they exhibit a comparatively large quantity of magnesia. The Little Miami at all points below Xenia receives its tributaries from the blue limestone region, abounding with blue clay-marl. This marl, we have ascertained, contains phosphates, and hence the abundance of these in its waters is explained. But the parallel part of Big Miami drawing its waters also from the blue limestone region, does not exhibit the same phenomenon; this is partly accounted for from the fact that the Big Miami receives a larger proportion of its waters from the cliff limestone. The specimens of water from Mad River and from the Big Miami, both above and below the mouth of Mad River, are really from the cliff limestone. The remainder of the course of the Great Miami, viz: from Dayton downwards, is in the blue limestone.

WATER FROM A SPRING AT THE BREWERY ON SYCAMORE HILL.

Column H. in the Tables.

By reference to the tables it will be seen that the sum of the ingredients of this specimen are greater than the solid matter from evaporating a standard quantity. This was probably owing to the acid solution of the solid matter being passed through a filter from which it dissolved lime, the precaution not having been taken to wash the filter previously with acid. This excess is 0,06 in 5000 grs. of the water.

This spring at the Brewery, we understand to have produced fatal cholera in all persons who used it during the prevalence of that epidemic in the city. The analysis reveals the fact that the spring abounded in the salts of lime. It contains ten times as much sulphate and muriate of lime

as any other water analyzed by Prof. Silliman or ourselves. It contains also more carbonate of lime than any other water. It is no place here to take up the speculations with regard to the causes of cholera, but we venture to present a few remarks with regard to this spring. Physiology represents life as a force which resists chemical and mechanical agents so far as to prevent their decomposing the vital organs, and as controling those agents in such a manner as to make them contribute to its own purposes. Diseases may be represented as a contest between life and those agents, or between life and some unnatural agent or poison in which the external agent has so far gained the advantage as to disturb or suspend some of the vital functions. Agreeably to this view it is evident that the unknown poison which causes epidemic cholera may not be sufficient alone to overcome the vital force. Yet, by the aid of other agents acting in conjunction, death may be the result. Now, cholera has occurred in too many instances where neither calcareous nor magnesian waters were used to allow us to consider these waters as the *cause* of the disease. But, as calcareous waters are known to produce diarrhea and a species of cholera in persons in robust health not accustomed to them, it is very natural to suppose that when the unknown cause of cholera has almost overcome the vital force the aid afforded by hard or cathartic waters will be sufficient to decide the point and produce death. This is commonly expressed by saying that the cholera poison is the predisposing cause, and the hard water the exciting one. I think it better to say the unknown cause of cholera alone might prove insufficient, but by the aid of an ally acting to the same point it gains a victory over life.

The waters used in Paris, France, are charged with sulphate of lime, which produces in almost all strangers, after a few days residence, a disease called the "Cholera de Seine," or Cholera de l'Etranger," for the river Seine is hard from the above named salt; and how fatal was the cholera in Paris? fatal from its able ally, hard water.

According to this view of the subject, the spring at the Brewery on Sycamore hill is admirably calculated to act as the aid of epidemic cholera in its hostility to human life.

WHITE WATER RIVER.—(FIRST SPECIMEN.)

Column I. in the Tables.

The jug in which this specimen was brought had contained vinegar, and was not thoroughly washed; so much did it contain that it converted the carbonates into acetates and dissolved the glazing from the jug; this was the source of the manganese which the water contained.

It may be as well here to state that waters for analysis should be placed in glass bottles, which should be thoroughly washed and then rinsed with the water they are to contain. After having filled the bottles, the corks should be forced in so as to displace the superabundant water and exclude all air, then they should be hermetically sealed and fully labeled.

The neglect of these precautions is frequently the source of great errors which the analyst has no way of correcting.

OF THE RESULTS AS PRESENTED IN THE TABLES.

The first step in the analysis of each specimen was to evaporate a standard quantity by measurement and weigh the whole solid residuum. obtained by simple evaporation. As, however, there are a few elements not attempted to be ascertained by quantity in the details, it is expected that the sum of the items will fall a little short of the solid residuum above named; the deficit is attributed to those unweighed items, No. 25, in the second table, where it will be seen that they amount in the most to a little over a grain in a gallon, except in the water brought from the White Water River, which was accidentally impure, and therefore not a sample of a natural water.

The business of an analyst is an occupation against the errors of which the public have no check, except the reliance upon the integrity and skill of the operator. Indeed, the analyst himself is liable to be deceived, unless he uses checks and balances, as in accounts in book-keeping. These checks upon a public work, like the present, we have endeavored to introduce in such a manner as to feel fully satisfied ourselves of the truth of the results.

The first table contains the original results from which the second was formed. We have introduced it here in order to guard against any errors of calculation by which the second table was made, and also to give the acids and bases uncombined so that their relative quantities can be easily seen.

The second table contains the substances combined according to the best authorities, presenting the whole matter in the usual form. For the purpose of comparison we have introduced Prof. Silliman's analyses of the eastern waters on the first part, and those of the western waters made by ourselves upon the second part of the page, constituting, however, one table in which the substances or constituents dissolved in the water are named in the left hand column.

This table gives the carbonates as proto-carbonates, (or one portion of carbonic acid to one of the base,) which is the state in which they are found in the residuum after evaporation, yet in the water they exist as per-carbonates (or two portions of carbonic acid to one of the base). The second portion of carbonic acid is necessary to form a soluble compound, and when the water is boiled the lime and magnesia are precipitated as proto-carbonates by half of the acid being expelled by the heat.

In the second table, No. 1 is the supply for the city of Philadelphia; No. 2 for New York; and No. 5 for Boston. Nos. 4 and 6 are small lakes in the vicinity of Boston; and No. 3 is a river in Massachusetts, emptying at Boston.

TABLE No. 1.

Contains the weight of the substances found in 5000 grains (by measurement) of each specimen of water.

NAME.	A. Ohio River 12 miles below Big Sandy, May 7, 1853.........	B. Ohio River at Cincinnati, Oct. 23, '52.	C. Little Miami River.	D. White Water River	E. Big Miami, below the junction of Mad River..............	F. Big Miami, above the jnnetion of Mad River..............	G. Mad River.........	H. Spring at the Brewery on Syc. Hill....	I. White Water River
Solid Matter	0.343	0.577	1.27	1.302	1.491	1.551	1.633	2.54 *	2.975
Lime	0.070219	0.157260	0.259149	0.487092	0.402739	0.538388	0.617586	1.191948	0.492953
Magnesia	0.022948	0.067709	0.105977	0.118154	0.211901	0.216788	0.207809	0.224633	0.103956
Potassa	....	0.000580	0.033254	....	0.000386	0.000773	Trace.	....	0.005606
Alumina	....	....	....	....	race.	....	....	....	Trace.
Silica (flint)	0.520000	0.023080	0.064770	0.018228	0.071568	0.007755	0.006775	0.061740	0.099662
Nitric and Organie Acid with Soda	0.093927	0.129011	0.087409	0.130948	0.115307	0.020282	0.005759	0.004940	0.947973
Phosphate of Lime	....	....	0.083920	....	....	....	....	....	....
Phosphate of Alumina	....	....	0.239770	....	....	....	....	....	....
Maganese	....	....	....	....	....	....	....	....	0.062475
Iron	Trace.	Trace.	Trace.	Trace.	....	....	Trace.	Trace.	Trace.
Sulphurie Acid	....	0.044683	0.040559	0.025435	0.201076	0.074931	0.045715	0.596010	0.037122
Chlorine	0.051807	0.024670	0.046132	0.003700	0.018749	0.018995	0.018009	0.172196	0.053534
Carbonic Acid	0.052099	0.130007	0.309060	0.518443	0.469274	0.673088	0.731347	0.753298	....
Total	0.343	0.577	1.27	1.302	1.491	1.551	1.633	3.004765	2.975
Analyzed by	J. M. Locke.								

* The "total" is greater in this analysis than the "solid matter;" by referring to page 10, remarks on column H. in the Tables the probable reasons will be found.

TABLE No. 2.

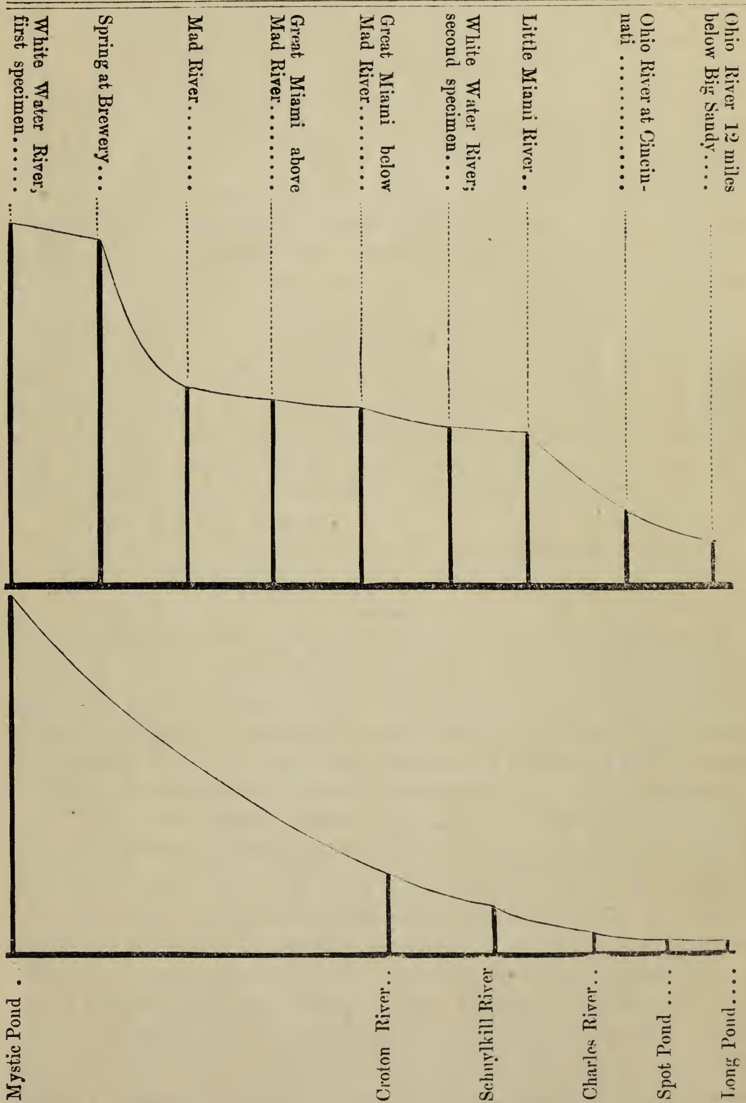
ANALYSES OF NATURAL WATERS,

Showing the quantity of the compound ingredients in American standard gallon (or 58372 grs.) of each of the specimens.

1	NAME.	NO. 1 Schuylkill River...	NO. 2 Croton River......	NO. 3 Charles River	NO. 4 Spot Pond.........	NO. 5 Long Pond.........	NO. 6 Mystic Pond.......	A. Ohio River 12 miles below Big Sandy ..	B. Ohio River at Cincinnati, Oct. 23, '52.	C. Little Miami River.	D. White Water River	E. Big Miami, below the junction of Mad River..............	F. Big Miami. above the junction of Mad River............	G. Mad River.........	H. Spring at the Brewery on Sye. Hill....	I. White Water River
3	Chloride of Potassium					.0380	.1590									
4	Chloride of Sodium	.1470	.1670	.1547	.3969	.0323	27.9110	.0400	.4773	.2230	.0232	.3627	.3675	.1169	.1425	.0852
5	Chloride of Calcium		.3720	.0420		.0308	.1544	.9165		.2551				.2205	2.1153	
6	Chloride of Magnesium	.0094				.0764				.3291	.0412			.0830	.7915	
7	Chloride of Alumina		.1660													
8	Chloride of Manganese															1.0197
9	Sulphate of Potash								.0125	.7180		.0083	.0167	Traee		.1210
10	Sulphate of Soda		.1530	.3816	.2276											
11	Sulphate of Lime		.2350	.2624			1.2190			.1499	.3048		.4945	.3445	10.5500	
12	Sulphate of Magnesia	.0570				.1020	1.9768		.7738	.0876	.1782	3.5154	.8671	.4985	1.1968	
13	Sulphate of Alumina						.4478									
14	Sulphate of Manganese															.7295
15	Phosphate of Lime				& Iron					.9797						
16	Phosphate of Alumina		.8320	.0973	.1081		.2810			2.7992						
17	Alumina					.0800						Trace.				Trace.
18	Silicic Acid (flint)	.0800	.0770	Trace.	Trace.	.0300	.5559	.6071	.2694	.7562	.2128	.8355	.0905	.0791	.7208	1.1635
19	Carbonate of Lime	1.8720	2.1310	.1610	.3722	.2380	.9894	.6260	3.2615	5.0330	9.8769	8.3524	10.7907	12.3543	15.0067	
20	Carbonate of Magnesia	.3510	.6620	.0399	.1420	.0630	.1698	.6028	.6201	2.5638	3.1263	3.1298	5.3890	5.3467	4.5553	
21	Carbonate of Manganese		Trace.													
22	Carbonate of Iron							Trace.	Trace.	Trace.	Trace.			Trace.		
23	Acetate of Magnesia															4.3084
24	Acetate of Lime with trace of Iron															16.2371
25	Salts of Soda with the Nitric and Organic Acids	1.6436	1.8650	.5291		.5295		1.2120	1.3215	.9319	1.4367	1.2023	.0910	.0209		11.0670
26	Total, or Solid Matter	4.2600	6.6600	1.6680	1.2468	1.2220	34.7671	4.0044	6.7361	14.8265	15.2001	17.4064	18.1070	19.0644	35.0788	34.7314
27	Carbonic Acid Gas in cubic inches	.3879	17.4180	.0464	38.7900	10.7190	10.3130	1.2913	7.5908	16.1947	26.1115	23.2596	19.9003	42.7878	39.1978	
28		Analyzed by.........Prof. B. Silliman, jr.						Analyzed by..........J. M. Locke.								

DIAGRAMS,

SHOWING THE RELATIVE AMOUNT OF SOLID MATTER IN A GIVEN QUANTITY OF WATER.



The Diagrams are on the principle that each twentieth of an inch of the ordinates represents a grain of solid matter when the quantity of water is a gallon; for example, the ordinate marked "Ohio River 12 miles below Big Sandy" is four-twentieths of an inch in length, and the weight of the solid matter of a gallon of the water was four grains and a slight fraction.

It is highly gratifying to see our citizens and city authorities attending to those subjects of scientific interest which tend to place us on a level with our neighbors (who are quite enough inclined to treat us as inferiors), and at the same time contribute to our convenience and happiness. It is not unfrequently that we see persons, even occupying public stations, entertaining a peculiar malignant hostility to every thing which can be called scientific—pronouncing even the word scientific with a contemptuous sneer. If science were what they assume it to be, pedentry and pretension, they would be justified. What is true science? *It is truth expressed in its simplest form, and applied to the benefit and happiness of mankind.* Who is ready to declare himself against science thus defined?

Nature has done much for the West. The broadness and transparent simplicity of our geology, where our materials are stratified in plains nearly horizontal, give a similar obvious simplicity to our agriculture and manufactures. In ascertaining the composition of our waters we receive aid from a knowledge of our easily learned geology. Pointing to the sandstone region as affording the purest waters, the limestone region as furnishing highly calcareous and fertilizing springs and the contacts of strata, as shale and limestone, yielding mineral springs containing iron and sulphur, while from the deep caverns of the sandstone we draw the salt for our food.

JOHN LOCKE, M. D.,
Prof. Chem. and Pharm.

JOSEPH M. LOCKE,
Assistant to the Prof. Chemistry, &c., Medical College of Ohio.

It is gratifying to me to be able to say that the manipulations and calculations of these analyses have been ably performed by my Assistant. He also drew up several parts of this Report, and has shown all of that industry and faithfulness which are so important in a work of the kind. Above all, he has shown that conscientious regard for the *indications of the balance,* that religious adherence to truth so desirable—not only in analysis—but in all the transactions of life. When he found, in one instance, an error of a small fraction of a grain (sixty-four-thousandths of a grain in five thousand of water) by which the sum of the items overrun the whole weight of solid matter as obtained by evaporation, he was very much concerned about it, and instead of forcing an agreement by subtracting a little from each item, as is not unfrequently done in such cases, he preferred recording the facts just as they had presented themselves. This conscientiousness in matters of physical research is a quality of a higher grade than perhaps he was aware of. As my son is now making Practical Chemistry a profession, I venture to recommend him to the patronage of the public. The interested relation which a father holds to a son is a good reason why he should not recommend him unwarrantably; but it is not a reason why he should withhold from him that credit which he knows to be due.

JOHN LOCKE.